SQUARING THE CIRCLE.

The problem of squaring the circle, to which allusion is so often made—without, however, being always clearly understood—consists in constructing a square whose area shall be exactly equal to that of a given circle. Unhappily, the problem is insoluble; we can only arrive at an approximate solution; and in the present day no one who has even an elementary acquaintance with the first principles of geometry will lose his time in the vain attempt to solve it completely, True geometricians have always been aware of the difficulty, or rather impossibility, of the task. In their investigations. they have merely aimed at approximating nearer and nearer to exactness; and not unfrequently they have been, as it were, surprised into discoveries in the various branches of mathematical science. But there has always been a class of men less enlightened and more daring, who, scarcely knowing what they wanted or what they were doing, yet pretended to discover the squaring of the circle, perpetual motion, and other things beyond human power. The problem of squaring the circle is as old as geometry itself. It occupied the thoughts even of philosophers in Greece, the very cradle of mathematical science. Anaxagoras employed himself about it in the prison where he was confined for having proclaimed the doctrine that God is one and alone above all. Aristophanes, the Molière of the Athenians, introduces the celebrated philosopher Meton upon the stage, and cannot devise any better method of bringing ridicule upon him than by making him promise to square the circle. It was Archimedes who first found out the approximate ratio of the circumference of a circle to its diameter. Apollonius, or Philo of Gadara, found ratios still nearer the exact truth; but what they were is not now known. The labours also of Adrian, Metius, Vietus, Zudolph, Van Keulen, Machin, and Lagny, in this direction of inquiry, are well known.

Cardinal de Cusa was the first of modern alchemist-geometricians. He fancied he had discovered the true method of squaring the circle, by making a circle or a cylinder roll along a plane surface until it had described its whole circumference; but he was proved by Regiomontanus to be in error. After him, towards the middle of the sixteenth century, a professor-royal of mathematics, Orontius Fineus, gained distinction by his remarkable fallacies on this subject. The celebrated Joseph Scaliger also indulged in these caprices. Thinking lightly of geometricians, he wished to show them the great superiority of a learned man like him. Vietus, Clavius, and others, having ventured to refute his mathematical reasoning, he became incensed, loaded them with abuse, and was more than ever convinced that geometricians had no common sense. About seventy years ago, M. Liger thought he had discovered the true solution, which had been for ages concealed from view, by demonstrating that the square root of 24 is equal to that of 25, and that that of 50 equals that of 49. His demonstration did not, he said, rest upon geometrical reasoning, which he detested, but upon the properties of figures.

There have been a number of bets and challenges in connexion with this problem at different times. The French Institute having been overwhelmed every year with voluminous packets on the squaring of the circle and perpetual motion, at length came to the resolution to receive no more upon these subjects. Yet only about a few years ago, on opening a paper which had been kept sealed for many years at the request of the author, as containing a precious discovery, it was found to be another attempt to solve the insoluble problem.

TUBULAR BRIDGE OVER THE WYE.

The engineering achievements of modern times have been so singularly characterised for originality and boldness of conception and success in execution, that the word "impossible," as applied to anything which may be required, appears, if not to be repudiated, yet practically, to be ignored. The difficulties which presented themselves in the formation of that mighty and elaborate system of locomotion, which has been established in this and in other countries, seem to have challenged the dormant energies of our engineers only to be vanquished; and one after another noble structures have been reared, not simply to promote in a high degree the welfare of man, but to declare with silent yet impressive eloquence the dignity of the intellectual endowments which have been conferred upon him, for the dominion of the material creation, by the Father of all.

One of the most remarkable and interesting engineering works of modern times is the railway bridge crossing the Wye at Chepstow, which has just been completed. In the planning out of the South Wales Railway, which is to unite Gloucester with Milford Haven, and has already been opened as far west as Carmarthen, it was found necessary to cross the Wye, near Chepstow; and the problem to be solved was not an easy one. As it is a navigable river, the admiralty required that the space over the mid-channel should not be less than 300 feet, and that a clear headway of fifty feet above the highest known tide should be secured; so that across this "tidal chasm" an iron bridge had to be hung, capable of supporting the heaviest burdens that passing trains could impose. The work obviously demanded the highest efforts of mechanical and constructive skill, but the bold and experienced mind of the engineer was not overtasked by the exigencies of the case; and Mr. Brunel has produced a work which is believed to combine perfect efficiency with singular economy of material. In proceeding to describe this remarkable structure, as the two lines of railway are supported by separate though perfectly similar means, it will be necessary to make particular reference only to one.

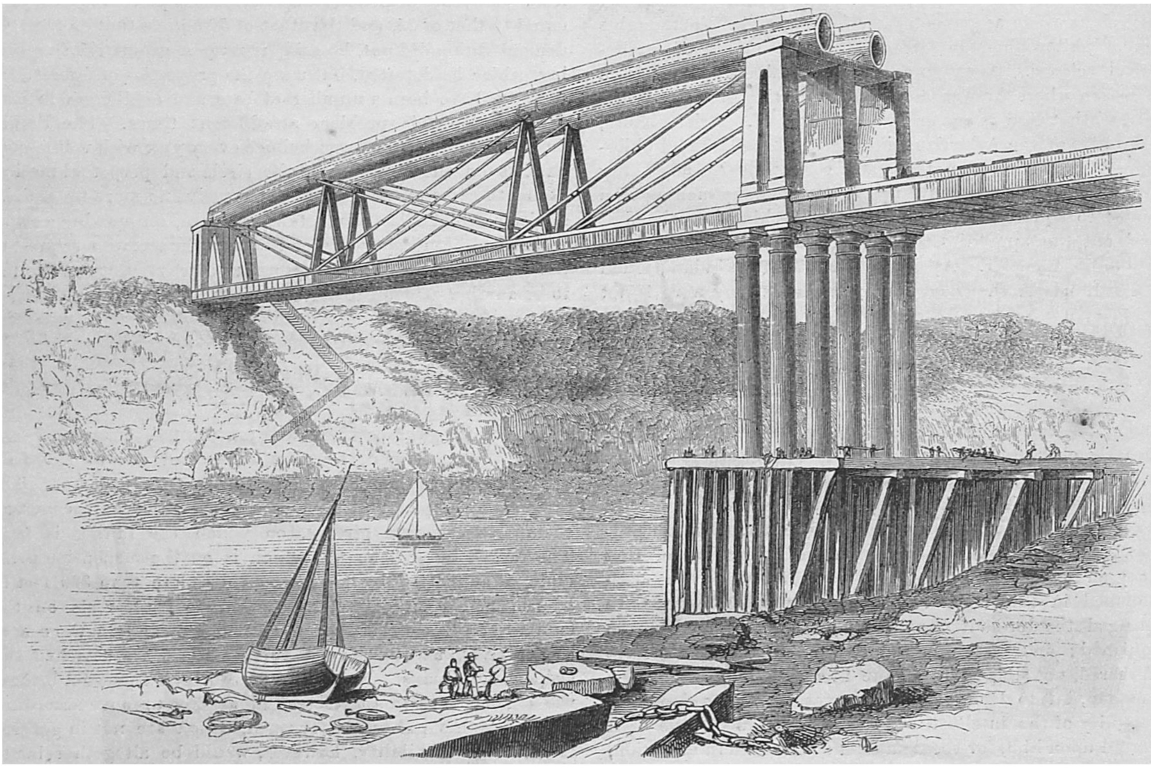
The bridge, which Mr. Brunel has erected, consists of four spans, three of about 100 feet each, and one of 290 feet, extending altogether from bank to bank for 610 feet. The three smaller spans rest upon iron piers, filled with concrete, sustaining cast-iron girders, on which the railing is laid. The fourth and chief span, which is on the suspension principle, is supported by means of a tube more than 300 feet in length, and 9 in diameter. The tube itself rests on the summit of piers erected on the east bank and in the centre of the river, and to the ends of the tubes are attached the suspending chains. Now, in an ordinary suspension bridge, the chains hang in a festoon, and are free to move according to the weights passing under them, which are not in general great. This flexibility, however, would be altogether inadmissible in a railway bridge, for the continuity of the rails would be destroyed if a very small deflexion took place when traversed by a heavy locomotive. With a view to supply the necessary rigidity, Mr. Brunel has introduced at every third part of the tube a stiff wrought-iron girder, firmly connecting the tube with the roadway girders, and, with the aid of other adjusting screws, the suspension chains are stretched as nearly straight as is desirable. Other diagonal chains connect these points, so that at whatever part of the bridge a train may be passing, its weight is distributed over all the tube and chains by these arrangements.

In the operations connected with the sinking of the cylinders which form the piers of the bridge, some curious facts came to light. The workmen had first to pass through nearly thirty feet of blue clay and sand, below which they met with a thin bed of peat containing timber, some solid oak, hazel nuts, and other substances of the same kind. They next came to several feet of fine blue gravel, and then they found the bed of boulders upon which the cylinders were originally intended to rest. After this was a bed of red marl, beneath which they discovered solid rock, resembling what is known as milestone grit, into which the cylinders were sunk. The mode in which this part of the work was performed was

ingenious :—"The cylinders were placed on planks to prevent them cutting into the soft mud. One by one, cylinders were added, until they had reached the top of the stage, about forty feet in height, which had been erected for the purpose of sinking the cylinders. The weight of this column then cut through the plank, and the cylinder sank about six feet into the mud. Men then descended into the cylinder, two or three working there at a time; and as they excavated the soil, so the cylinder gradually sank, and as the column descended, fresh cylinders were added at the top. The excavation then continued, without interruption, until a depth of about seventeen feet was attained, at which point the water broke in from below in such force as to require the constant operation of two thirteen-inch pumps worked by an engine. The water burst in at a moment's warning, as soon as the spring was tapped; and the most remarkable phenomenon attending this occurrence was the fact, that the spring-water invariably rose in the cylinder exactly to that height at which the tube was standing in the river at this moment. That it was not an irruption of the water of the Wye is considered to be beyond dispute, inasmuch as the river at this point is, from the action of the tide, always tainted with mud, which is held in solution in great quantities at all times, while the water which rushed into the cylinder from below was of exceeding purity, and contained not a particle of salt."*

From the time of the first tapping of the spring, the pumps of a thirty-horse power engine had to be kept at work until the cylinders had been sunk to the rock; they were then filled with concrete. This irruption of water, at the depth of seventeen feet from the level of the bed of the river, was the same in the sinking of all the cylinders for the centre or principal pier; but the water did not interrupt the work to so great an extent in making the other piers, and the workmen proceeded to a greater depth. The spring appeared to be in the bed of gravel, about twelve feet from the point where it first burst into the cylinder. One fact, which demanded special provision in the computations of the engineer was, that the spring tides on the river Wye rise here from fifty to sixty feet—a greater elevation than in any other river in the kingdom.

Interesting as is this remarkable structure in itself, it is still more important as a link of union between the west-centre of England, and the increasingly prosperous districts of the south of Wales. For some months after the opening of a considerable portion of the South Wales Railway, there was a hiatus at Chepstow, till the bridge could be completed, and while passengers found that it was no small inconvenience to be conveyed by omnibus over a rough country, and then over Chepstow town-bridge to the station on the other side the river, there was even more serious difficulty as regards the goods and mineral traffic, to carry on which was impracticable on any large scale. In the summer of last year the first tube connecting the line was opened for traffic, and within a few weeks the second tube has been raised, the final arrangements completed, and the bridge finished. And now, by one of the most delightful rides which can be found, the traveller is borne along the banks of the glorious Severn till he reaches a land of surpassing beauty, and far away from the toil and turmoil of business may fill his mind with scenes of loveliness and delight, and store his heart with memories of happiest hours, which he will ever love to recall as he thinks of Chepstow, Tintern, and the Wye.



SECTION OF THE CHEPSTOW TUBULAR BRIDGE.

The proportions of this colossal structure may be inferred from the large amounts of material consumed in its erection, of which the following are the principal items :—

	TONS.
Wrought-iron used in three spans of 100 feet each, double line	277
Wrought-iron in girders, &c., of main tube, of 300 feet span, double line	278
Two wrought-iron tubes	302
Suspending links in main chains and diagonals	256
Total employed, including nails, not mentioned above	1231
Cast iron	1003

Masonry in abutment and pier, 3240 cubic yards.
Total cost, above £65,000.

* "Our Iron Roads."